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EXPLAINED: 2020 NOBEL PRIZE IN PHYSICS

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The 2020 Nobel Prize in Physics was awarded with one half to Roger Penrose and the other half jointly to Reinhard Genzel and Andrea Ghez.

With this award Professor Andrea Ghez becomes the fourth woman to be awarded the Nobel Prize in Physics after Marie Curie (1903), Maria Goeppert-Meyer (1963) and Donna Strickland (2018).

Roger Penrose has been awarded the prize because of his theoretical work which showed that black holes can form and exist as solutions of Einstein's field equations.

Albert Einstein published his general theory of relativity on November 18, 1915. Soon after that (January 13, 1916) German astronomer Karl Schwarzschild found a solution to these equations that showed a singularity – a point where physical quantities take infinitely large or infinitesimally small values and therefore are not realisable physically.

For a long time this was a bit of an embarrassment to Einstein as it appeared his equations had unphysical solutions and may not be correct.

In 1939, Robert Oppenheimer and his student Hartland Snyder came up with a paper where they identified and interpreted Schwarzschild's result as a horizon beyond which the star closes off and can only be felt by its gravitational field. However, Einstein did not agree with this yet.

Around the mid-1960s strange phenomena were being discovered experimentally by astrophysicists that led John Wheeler to reconsider the physics of gravitational collapse. He suggested to Roger Penrose to revisit this concept. Using novel mathematics and topology he built up the mechanism by which such a collapse can occur and a black hole can form.

This was the theoretical discovery that made "black hole" an accepted concept in physics. The name was first used by American physicist Robert Dicke in 1960, it was popularised by John Wheeler.

Two independent groups of observational astrophysicists let by Prof Genzel and Prof Ghez respectively have been monitoring the centre of the Milky Way for nearly three decades. They were studying the compact radio source Sagittarius A* near the galaxy's centre which we now know to be a Supermassive Black hole. Saggittarius A* is 25,000 light years away.

Black Holes: what are we seeing when we see one? | Podcast

The working hypothesis was this: The stars around the galactic centre appeared to be moving in orbits around some source.

If this source was pointlike, they will move in Keplerian orbits – that is orbits similar to what planets like earth mars etc have around their stars. If the mass at the centre was spread out among many objects, the stars orbiting them will not have perfect keplerian orbits.

Just imagine their challenging experiment from this great distance of 25,000 light years. They have to identify and track individual stars and not be distracted by interstellar dust.

Yet they managed to keep tracking the stars using near infrared light telescopes and successfully proved that the mass was indeed concentrated at a centre - Sagittarius A*.

They spotted stars which the teams named S2 and So2 which orbited Sagittarius A* in 16 years, taking elliptical orbit.

The interpretation of this was that Sagittarius A* is indeed a supermassive black hole.

The imaging of the black hole silhouette by the Event Horizon Telescope further establishes the existence of supermassive black holes, thereby validating the prize this year.

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